ANNUAL REPORT
to the
GOVERNMENTS
of
UNITED STATES and CANADA

COLUMBIA RIVER TREATY

PERMANENT ENGINEERING BOARD

Ottawa, Ontario

30 SEPTEMBER 1959

90-05067/

COLUMBIA RIVER TREATY PERMANENT ENGINEERING BOARD

CANADA · UNITED STATES

CANADIAN SECTION
G.M. MacNABB, Chairman
D.H. Horswill, Member

UNITED STATES SECTION
L.A. DUSCHA, Chairman
R.H. Wilkerson, Member

31 December 1989

The Honorable James Baker
The Secretary of State
Washington, D.C.

The Honourable Jake Epp
Minister of Energy, Mines and Resources
Ottawa, Ontario

Gentlemen:

Reference is made to the Treaty between the United States of America and Canada, relating to co-operative development of the water resources of the Columbia River basin, signed at Washington, D.C., on 17 January 1961.

In accordance with the provisions of Article XV paragraph 2(e), there is submitted herewith the twenty-fifth Annual Report, dated 30 September 1989, of the Permanent Engineering Board.

The report sets forth results achieved and benefits produced under the Treaty for the period from 1 October 1988 to 30 September 1989.

Respectfully submitted:

For the United States

Lloyd A. Duscha, Chairman

Ronald H. Wilkerson

For Canada

G.M. MacNabb, Chairman

D.H. Horswill

COLUMBIA RIVER BASIN

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PERMANENT ENGINEERING BOARD

Washington, D.C. **Ottawa, Ontario**

30 September 1989

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Photographs supplied by the British Columbia Hydro and Power Authority and the U.S. Army Corps of Engineers.

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SUMMARY

The twenty-fifth Annual Report of the Permanent Engineering Board is submitted to the Governments of the United States and Canada in compliance with Article XV of the Columbia River Treaty of 17 January 1961. The status of projects, progress of Entity studies, operation of Duncan, Arrow, Mica and Libby reservoirs, and the resulting benefits are described.

The Duncan, Arrow, Mica and Libby storage projects were operated throughout the year in accordance with the objectives of the Treaty and the terms of operating plans developed by the Entities. Operations under an agreement between the Entities relating to the use of non-Treaty storage and refill enhancement for Mica and Arrow reservoirs did not conflict with Treaty operations. As a result of low natural flows in the basin, Treaty reservoirs were not required to be operated on a daily basis for flood control purposes during the year. (Pages 26-33)

Studies pertaining to development of the hydrometeorological network and power operating plans are being continued by the Entities to ensure operation of projects in accordance with the terms of the Treaty.

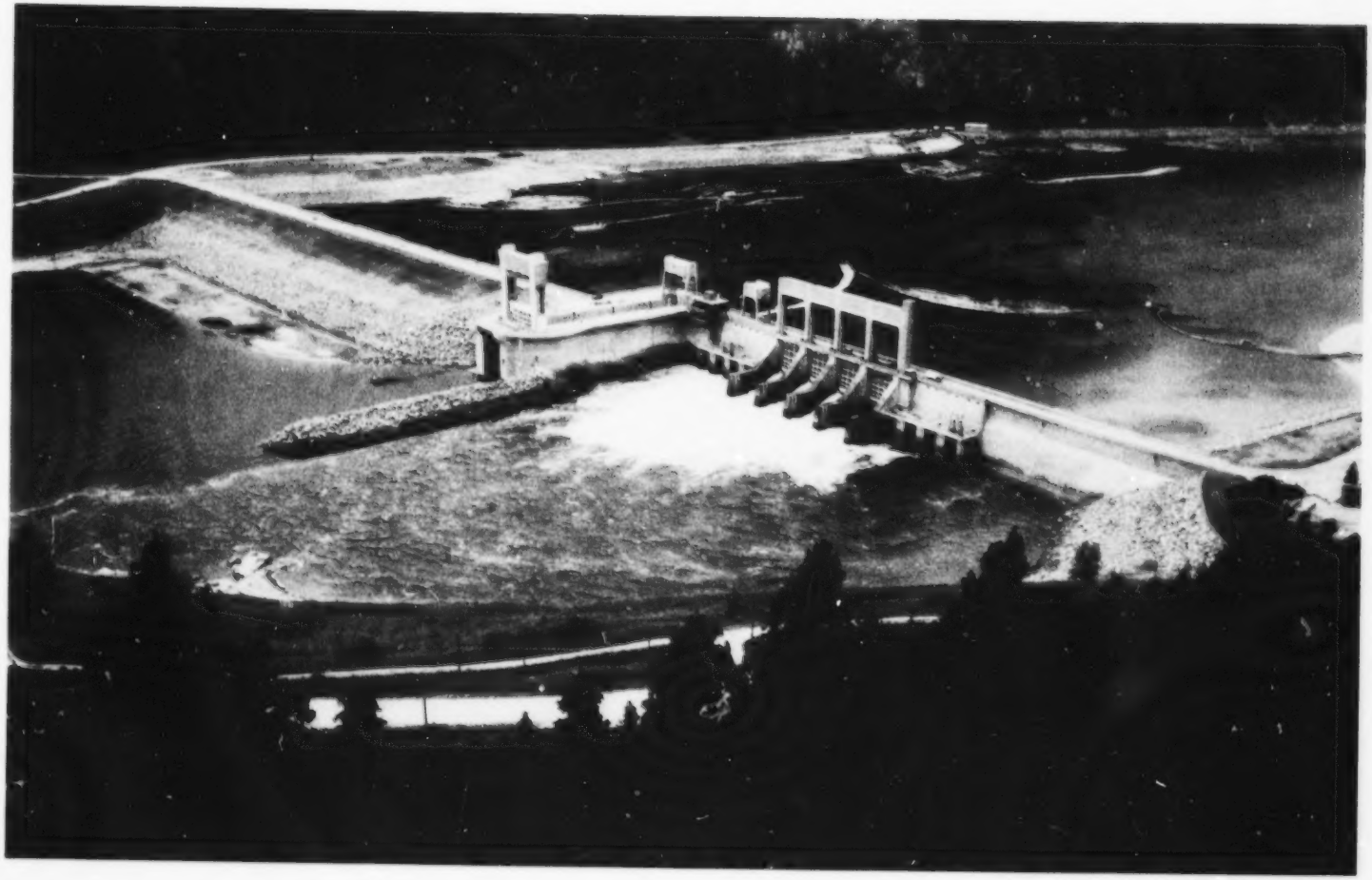
During the previous report year, the Entities signed two agreements relating to changes in procedures for developing assured operating plans and determining downstream power benefits. These agreements have resolved concerns which the Board had expressed in recent annual reports and have allowed the Entities to complete the 1993-94 Assured Operating Plan and Determination of Downstream Power Benefits. The corresponding documents for 1994-95, due at the beginning of the 1989-90 report year, have not yet been received but are expected to be available early in 1990. (Pages 21-24)

The Board concludes that the objectives of the Treaty are being met.

INTRODUCTION

The Columbia River Treaty, which provides for cooperative development of the water resources of the Columbia River basin, was signed in Washington, D.C. on 17 January 1961 by representatives of the United States and Canada. Article XV of the Treaty established a Permanent Engineering Board and specified that one of its duties would be to "make reports to Canada and the United States of America at least once a year of the results being achieved under the Treaty . . ."

This Annual Report, which covers the period 1 October 1988 to 30 September 1989, describes activities of the Board, progress being achieved by both countries under the terms of the Treaty, operation of the Treaty projects, and the resulting benefits. Summaries of the essential features of the Treaty and of the responsibilities of the Board and of the Entities are included. The report notes that the two major agreements relating to principles of operation and to changes to the procedures for the preparation of Assured Operating Plans and Determination of Downstream Power Benefits, signed in the previous report year, facilitate the meeting of Treaty objectives. The report provides discussion regarding the operations of the Treaty reservoirs and of the resulting power and flood control benefits, and presents the conclusions of the Board.



HUGH KEENLEYSIDE DAM Columbia River, British Columbia
Concrete spillway and discharge works with navigation lock and earth dam.

THE COLUMBIA RIVER TREATY

General

The Columbia River Treaty was signed in Washington, D.C. on 17 January 1961 and was ratified by the United States Senate in March of that year. In Canada ratification was delayed. Further negotiations between the two countries resulted in formal agreement by an exchange of notes on 22 January 1964 to a Protocol to the Treaty and to an Attachment Relating to Terms of Sale. The Treaty and related documents were approved by the Canadian Parliament in June 1964.

The Canadian Entitlement Purchase Agreement was signed on 13 August 1964. Under the terms of this agreement Canada's share of downstream power benefits resulting from the first thirty years of scheduled operation of each of the storage projects was sold to a group of electric utilities in the United States known as the Columbia Storage Power Exchange.

On 16 September 1964 the Treaty and Protocol were formally ratified by an exchange of notes between the two governments. The sum of $253.9 million (U.S. funds) was delivered to the Canadian representatives as payment in advance for the Canadian entitlement to downstream power benefits during the period of the Purchase Agreement. On the same date at a ceremony at the Peace Arch Park on the International Boundary the Treaty and its Protocol were proclaimed by President Johnson, Prime Minister Pearson, and Premier Bennett of British Columbia.

Features of the Treaty and Related Documents

The essential undertakings of the Treaty are as follows:

(a) Canada will provide 15.5 million acre-feet of usable storage by constructing dams near Mica Creek, the outlet of Arrow Lakes and Duncan Lake, in British Columbia.

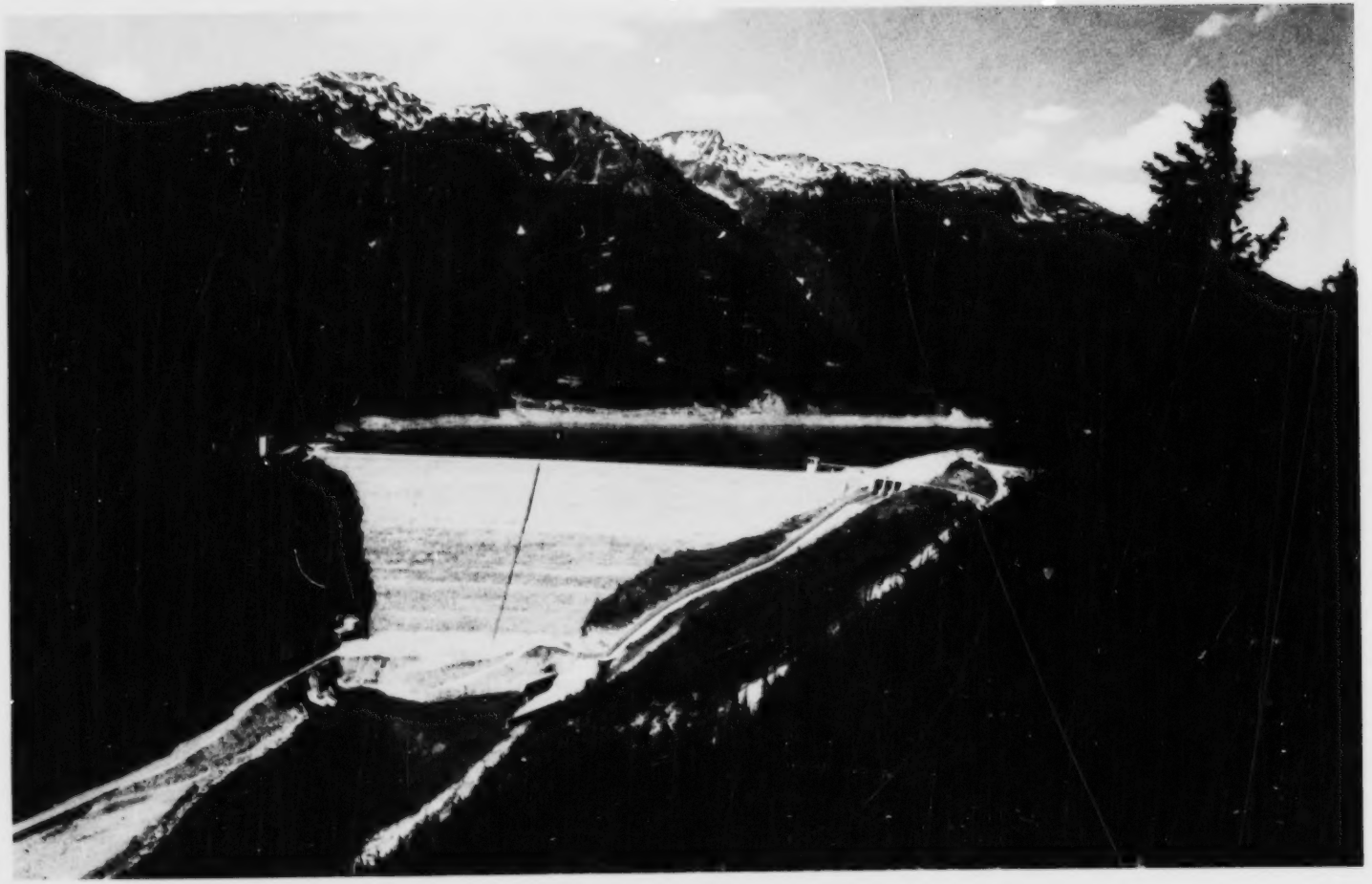
(b) The United States will maintain and operate hydroelectric power facilities included in the base system and any new main-stem projects to make the most effective use of improved streamflow resulting from operation of the Canadian storage. Canada will operate the storage in accordance with procedures and operating plans specified in the Treaty.

(c) The United States and Canada will share equally the additional power generated in the United States as a result of river regulation by upstream storage in Canada.

(d) On commencement of the respective storage operations the United States will make payments to Canada totalling $64.4 million (U.S. funds) for flood control provided by Canada.

(e) The United States has the option of constructing a dam on the Kootenai River near Libby, Montana. The Libby reservoir would extend some 42 miles into Canada and Canada would make the necessary Canadian land available for flooding.

(f) Both Canada and the United States have the right to make diversions of water for consumptive uses and, in addition, after September 1984 Canada has the option of making for power purposes specific diversions of the Kootenay River into the headwaters of the Columbia River.



MICA DAM Columbia River, British Columbia
The earth dam showing the spillway at the right. The underground powerhouse is at the left.

(g) Differences arising under the Treaty which cannot be resolved by the two countries may be referred by either to the International Joint Commission or to arbitration by an appropriate tribunal as specified by the Treaty.

(h) The Treaty shall remain in force for at least 60 years from its date of ratification, 16 September 1964.

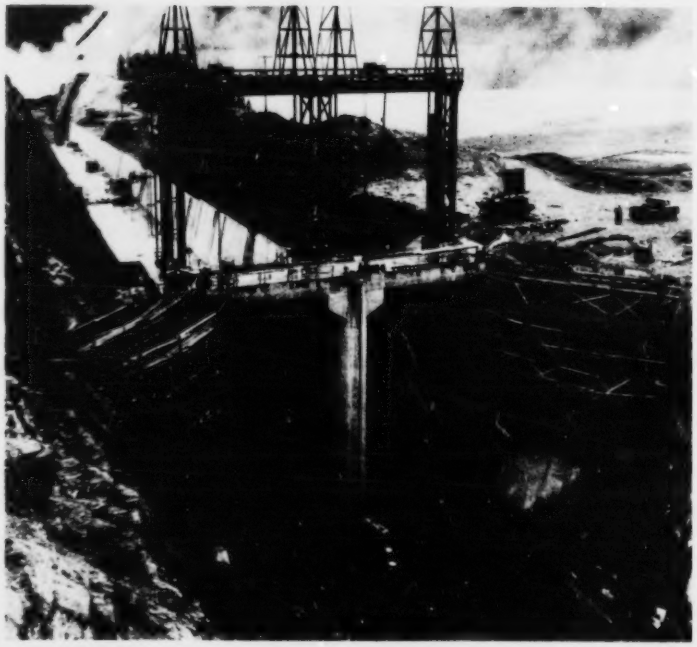
The Protocol of January 1964 amplified and clarified certain terms of the Columbia River Treaty. The Attachment Relating to Terms of Sale signed on the same date established agreement that under certain terms Canada would sell in the United States its entitlement to downstream power benefits for a 30-year period. The Canadian Entitlement Purchase Agreement of 13 August 1964 provided that the Treaty storages would be operative for power purposes on the following dates:

Duncan storage	1 April 1968
Arrow storage	1 April 1969
Mica storage	1 April 1973

PERMANENT ENGINEERING BOARD

General

Article XV of the Cclumbia River Treaty established a Permanent Engineering Board consisting of two members to be appointed by Canada and two members by the United States. Appointments to the Board were to be made within three months of the date of ratification. The duties and responsibilities of the Board were also stipulated in the Treaty and related documents.



SPILLWAY CONSTRUCTION
at Duncan Dam in 1967.

Establishment of the Board

Pursuant to Executive Order No. 11177 dated 16 September 1964 the Secretary of the Army and the Secretary of the Interior on 7 December 1964 appointed two members and two alternate members to form the United States Section of the Permanent Engineering Board. Pursuant to the Department of Energy Organization Act of 4 August 1977 the appointments to the United States Section of the Board are now made by the Secretary of the Army and the Secretary of Energy. The members of the Canadian Section of the Board were appointed by Order in Council P.C. 1964-1671 dated 29 October 1964. Each member was authorized to appoint an alternate member. On 11 December 1964 the two governments announced the composition of the Board.

The names of Board members, alternate members and secretaries are shown in Appendix A. It is noted that during the report year Mr. D.H. Horswill was designated as a Board member for Canada and on 12 October 1989 succeeded Mr. T.R. Johnson. Also, Dr. D.A. Kasianchuk succeeded Mr. H.M. Hunt as an alternate member for Canada.

Duties and Responsibilities of the Board

The general duties and responsibilities of the Board to the governments, as set forth in the Treaty and related documents, include:

(a) assembling records of the flows of the Columbia River and the Kootenay River at the Canada-United States of America boundary;

(b) reporting to Canada and the United States of America whenever there is substantial deviation from the hydroelectric and flood control operating plans and if appropriate including in the report recommendations for remedial action and compensatory adjustments;

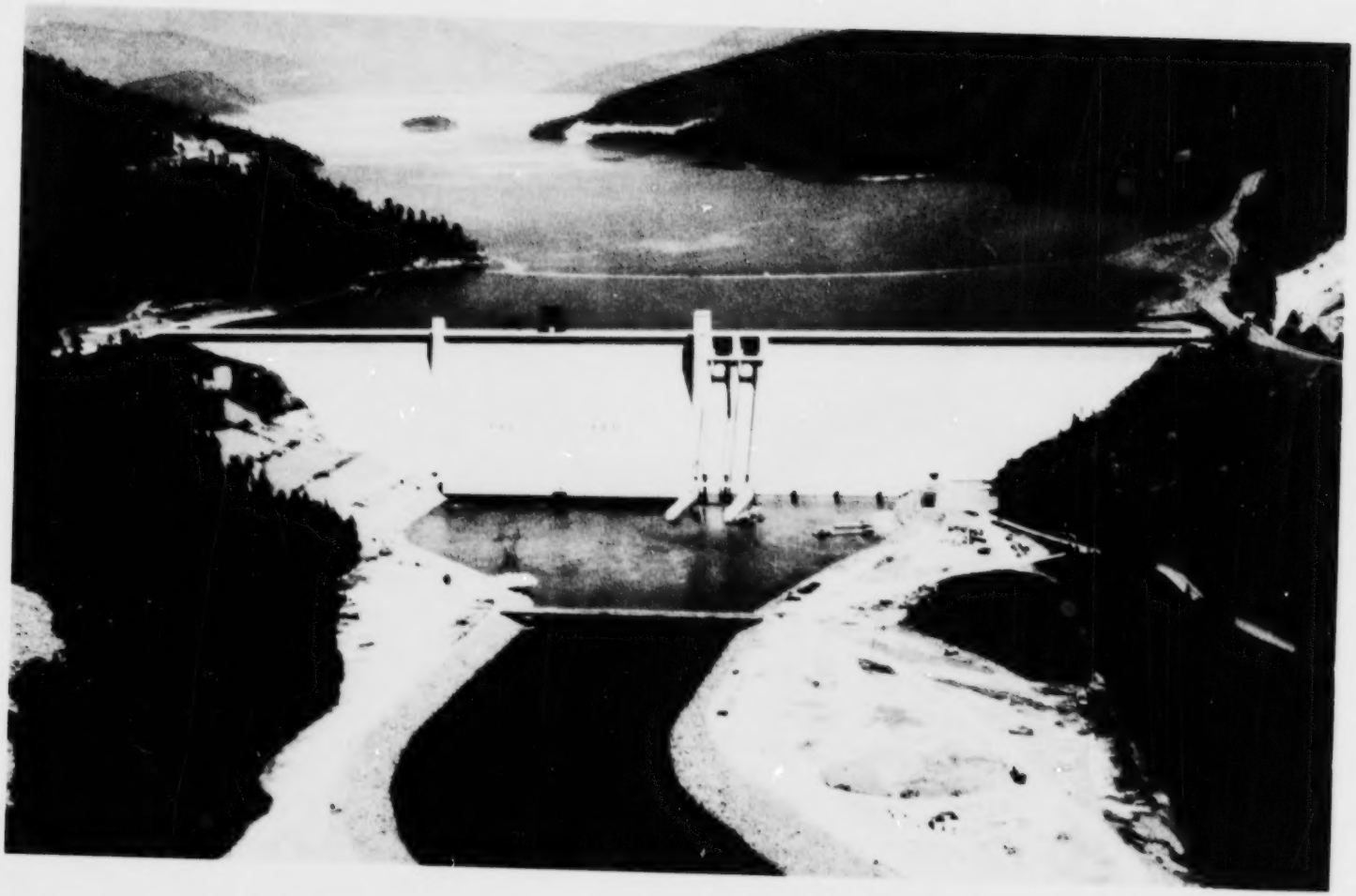
(c) assisting in reconciling differences concerning technical or operational matters that may arise between the entities;

(d) making periodic inspections and requiring reports as necessary from the entities with a view to ensuring that the objectives of the Treaty are being met;

(e) making reports to Canada and the United States of America at least once a year of the results being achieved under the Treaty and making special reports concerning any matter which it considers should be brought to their attention;

(f) investigating and reporting with respect to any other matter coming within the scope of the Treaty at the request of either Canada or the United States of America;

(g) consulting with the entities in the establishment and operation of a hydrometeorological system as required by Annex A of the Treaty.



LIBBY DAM — Kootenai River, Montana
The dam and reservoir, Lake Koocanusa. The powerhouse is at the left of the spillway.

ENTITIES

General

Article XIV(1) of the Treaty provides that Canada and the United States shall each designate one or more entities to formulate and execute the operating arrangements necessary to implement the Treaty. The powers and duties of the entities are specified in the Treaty and its related documents.

Establishment of the Entities

Executive Order No. 11177, previously referred to, designated the Administrator of the Bonneville Power Administration, Department of the Interior, and the Division Engineer, North Pacific Division, Corps of Engineers, Department of the Army, as the United States Entity with the Administrator to serve as Chairman. Pursuant to the Department of Energy Organization Act of 4 August 1977 the Bonneville Power Administration was transferred to the Department of Energy. Order in Council P.C. 1964-1407 dated 4 September 1964 designated the British Columbia Hydro and Power Authority as the Canadian Entity.

The names of the members of the two Entities are shown in Appendix B.

Power and Duties of the Entities

In addition to the powers and duties specified elsewhere in the Treaty and related documents, Article XIV(2) of the Treaty requires that the entities be responsible for:

(a) coordination of plans and exchange of information relating to facilities to be used in producing and obtaining the benefits contemplated by the Treaty,

(b) calculation of and arrangements for delivery of hydroelectric power to which Canada is entitled for providing flood control,

(c) calculation of the amounts payable to the United States for standby transmission services,

(d) consultation on requests for variations made pursuant to Articles XII(5) and XIII(6),

(e) the establishment and operation of a hydrometeorological system as required by Annex A,

(f) assisting and cooperating with the Permanent Engineering Board in the discharge of its functions,

(g) periodic calculation of accounts,

(h) preparation of the hydroelectric operating plans and the flood control operating plans for the Canadian storage together with determination of the downstream power benefits to which Canada is entitled,

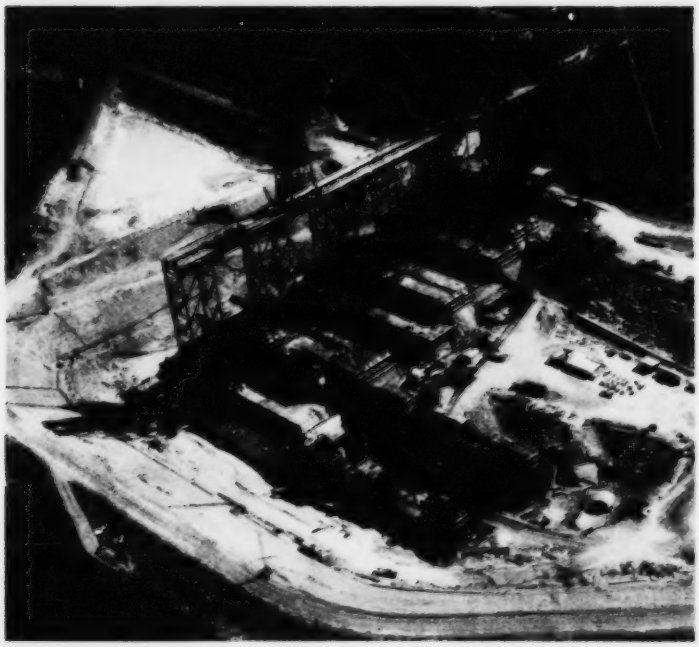
(i) preparation of proposals to implement Article VIII and carrying out any disposal authorized or exchange provided for therein,

(j) making appropriate arrangements for delivery to Canada of the downstream power benefits to which Canada is entitled including such matters as load factors for delivery, times and points of delivery, and calculation of transmission loss,

(k) preparation and implementation of detailed operating plans that may produce results more advantageous to both countries than those that would arise from operation under the plans referred to in Annexes A and B.

Article XIV(4) of the Treaty provides that the two governments may, by an exchange of notes, empower or charge the entities with any other matter coming within the scope of the Treaty.

DAM CONSTRUCTION
at Libby during 1968.



ACTIVITIES OF THE BOARD

Meetings

The Board met in Vancouver, British Columbia on 1 December 1988 to review progress under the Treaty and to discuss preparation of the Board's Annual Report. The Board met with the Entities on the same day to discuss Entity studies and general progress. The Entities briefed the Board on the two Entity agreements signed in 1988, one on principles and the other on procedures for the preparation of Assured Operating Plans and Determination of Downstream Power Benefit Studies.

Reports Received

Throughout the report year the Canadian Entity provided the Board with weekly reports on operation of the Canadian storage reservoirs and with daily flow forecasts during the freshet season for the northern part of the Columbia River basin. The United States Entity provided monthly reports on the operation of the Libby storage reservoir. The Entities also provided the following documents and reports and made copies of computer printouts of studies for the Assured Operating Plan and downstream power benefit calculations available for review:

— Annual Report of Columbia River Treaty, Canadian and United States Entities 1 October 1987 through 30 September 1988

— Detailed Operating Plan for Columbia River Treaty Storage 1 August 1988 through 31 July 1989 plus a copy of the Entities' agreement on this document

— Assured Operating Plan and Determination of Downstream Power Benefits for Operating Year 1992-93, plus a copy of the Entities' agreement on this document, September 1988

— Assured Operating Plan and Determination of Downstream Power Benefits for Operating Year 1993-94, plus a copy of the Entities' agreement on this document, September 1989

— Report on the use of Priest Lake in Treaty Steps II and III Studies, plus a copy of the Operating Committee's concurrence with this report, March 1989.

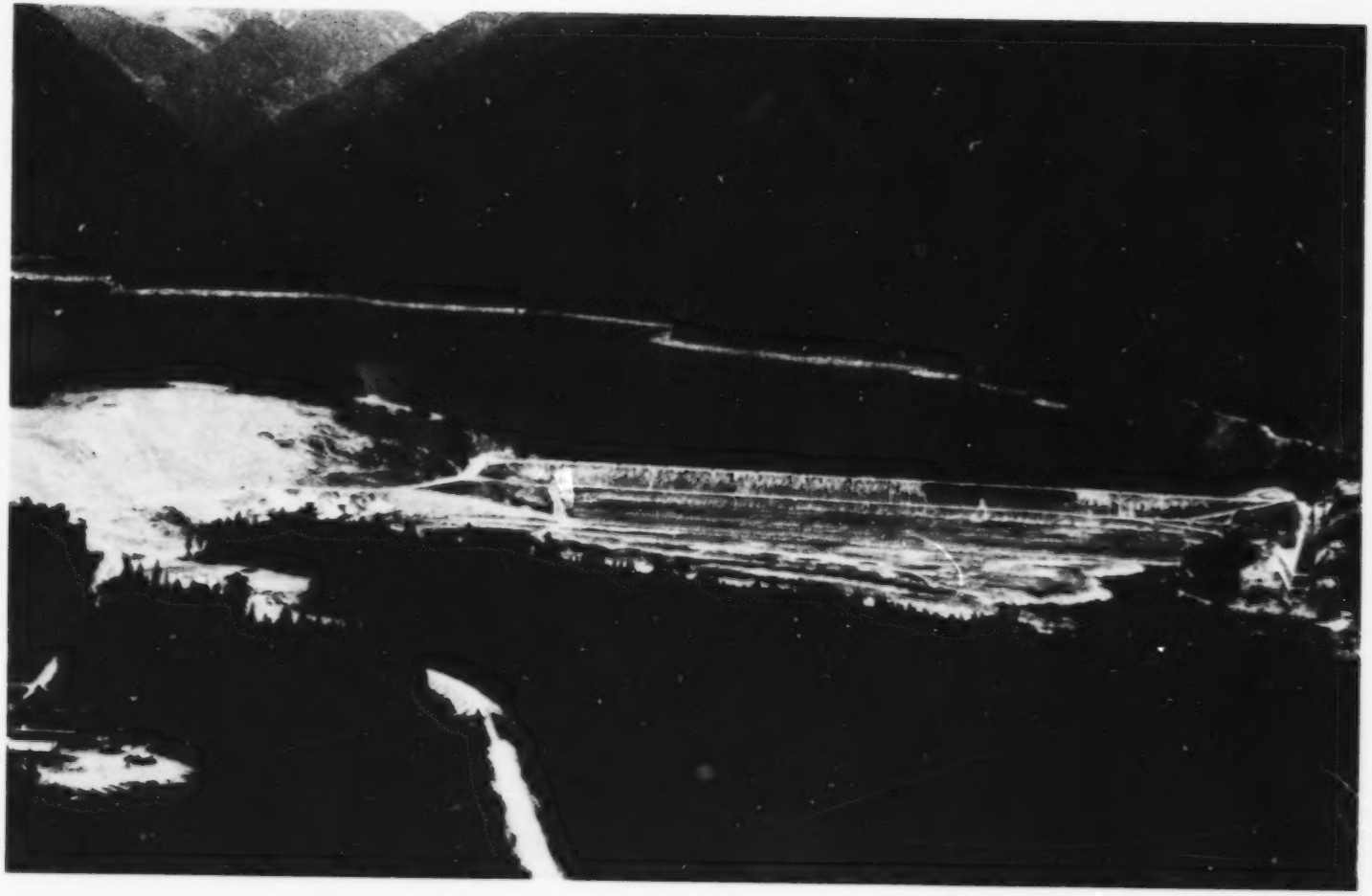
Subsequent to the end of this report year, the Board received the following documents and reports from the Entities:

— Annual Report of the Columbia River Treaty, Canadian and United States Entities 1 October 1988 through 30 September 1989

— Detailed Operating Plan for Columbia River Treaty Storage 1 August 1989 through 31 July 1990, plus a copy of the Entities' agreement on this document.

Report to Governments

The twenty-fourth Annual Report of the Board was submitted to the two governments on 31 December 1988.



DUNCAN DAM Duncan River, British Columbia
The earth dam with discharge tunnels to the left and spillway to the right.

PROGRESS

General

The results achieved under the terms of the Treaty include construction of the Treaty projects, development of the hydrometeorological network, annual preparation of power and flood control operating plans, and the annual calculation of downstream power benefits. The three Treaty storage projects in British Columbia, the Duncan, Arrow and Mica projects, produce power and flood control benefits in both Canada and the United States. The Libby storage project provides power and flood control benefits in both countries. In the United States increased flow regulation provided by Treaty projects has facilitated the installation of additional generating capacity at existing plants on the Columbia River. In Canada completion of the Canal Plant on the Kootenay River in 1976, installation of generators at Mica Dam in 1976-77 and the completion of the Revelstoke project in 1984 have caused power benefits to increase substantially. This amounts to some 4,000 megawatts of generation in Canada that may not have been installed without the Treaty. In addition, the installation of generating capacity at Hugh Keenleyside Dam and at the Murphy Creek Site near Trail, British Columbia is planned for the future.

The Treaty provides Canada with the option, commencing in 1984, of diverting the Kootenay River at Canal Flats into the headwaters of the Columbia River. The British Columbia Hydro and Power Authority has completed engineering feasibility and detailed environmental studies of the potential diversion.

The locations of the above projects are shown on Plate 1 in Appendix D.

Status of the Treaty Projects

Duncan Project

Duncan Dam, the smallest Treaty project, was scheduled by the Sales Agreement for operation by 1 April 1968 and was the first of the Treaty projects to be completed. It became fully operational on 31 July 1967, well in advance of Treaty requirements.

The earthfill dam, about 130 feet high, is located on the Duncan River a few miles north of Kootenay Lake. The reservoir behind the dam extends for about 27 miles and provides 1,400,000 acre-feet of usable storage which is all committed under the Treaty. There are no power facilities included in this project.

The project is shown in the picture on page 16 and project data are provided in Table 1 of Appendix D.

Arrow Project

The Hugh Keenleyside Dam, at the outlet of the Arrow Lakes, was the second Treaty project to be completed. It became operational on 10 October 1968 well ahead of the date of 1 April 1969 scheduled by the Sales Agreement. The project at present has no associated power facilities, however, installation of generators is planned for the future.

The dam consists of two main components: a concrete gravity structure which includes the spillway, low-level outlets and navigation lock and an earthfill section which rises 170 feet above the riverbed. The reservoir, about 145 miles long, includes both the Upper and Lower Arrow Lakes, and provides 7,100,000 acre-feet of Treaty storage.

The project is shown in the picture on page 2 and project data are provided in Table 2 of Appendix D.

PLACING EARTHFILL
at night, Mica Dam 1969.

Mica Project

Mica Dam, the largest of the Treaty projects, was scheduled by the Sales Agreement for initial operation on 1 April 1973. The project was declared operational and commenced storing on 29 March 1973.

Mica Dam is located on the Columbia River about 85 miles north of Revelstoke, British Columbia. The earthfill dam rises more than 800 feet above its foundation and creates a reservoir 135 miles long, Kinbasket Lake, with a storage capacity of 20,000,000 acre-feet. The project utilizes 12,000,000 acre-feet of live storage of which 7,000,000 acre-feet are committed under the Treaty.

The underground powerhouse has space for a total of six 434 megawatt units with a total capacity of 2,604 megawatts. The first two generators were placed in service late in 1976 and the last of the initial four units commenced operation in October 1977.

The project is shown in the picture on page 5 and project data are provided in Table 3 of Appendix D.

Libby Project in the United States

Libby Dam is located on the Kootenai River 17 miles northeast of the town of Libby, Montana. Construction began in the spring of 1966, storage has been fully operational since 17 April 1973, and commercial generation of power began on 24 August 1975, coincident with formal dedication of the project. The concrete gravity dam rises 370 feet above the riverbed and creates Lake Koocanusa which is 90 miles long and extends 42 miles into Canada. Lake Koocanusa has a gross storage of 5,869,000 acre-feet, of which 4,980,000 acre-feet are usable for flood control and power purposes. The Libby powerhouse, completed in 1976, had four units with a total installed capacity of 420 megawatts.

Construction of four additional units was initiated during fiscal year 1978 and the turbines have been installed. However, Congressional restrictions imposed in the 1982 Appropriations Act provide for completion of only one of these units. That unit became available for service late in 1987. The total installed capacity for the five units is 525 megawatts.

The Libby project is shown in the picture on page 10 and project data are provided in Table 4 of Appendix D.

Libby Project in Canada

Canada has fulfilled its obligation to prepare the land required for the 42-mile portion of Lake Koocanusa in Canada. British Columbia Hydro and Power Authority has assumed responsibility for reservoir maintenance and debris clean-up.

EARTH-MOVING MACHINERY
at Mica Dam, 1969.

Hydrometeorological Network

One of the responsibilities assigned to the Entities by the Treaty is the establishment and operation, in consultation with the Permanent Engineering Board, of a hydrometeorological system to obtain data for detailed programming of flood control and power operation. This system includes snow courses, meteorological stations and streamflow gauges. The Columbia River Treaty Hydrometeorological Committee, formed by the Entities, makes recommendations on further development of the Treaty Hydrometeorological System.

In developing the hydrometeorological network, the Entities, with the concurrence of the Board, adopted a document in 1976 which defines the Columbia River Treaty Hydrometeorological System Network and sets forth a method of classifying facilities into those required as part of the Treaty System and those of value as Supporting Facilities. During the 1976-77 report year, the Entities, with the concurrence of the Board, adopted a plan for exchange of operational hydrometeorological data. That plan is still in force.

In the 1985-86 report year the Entities provided the Board with a report "Revised Hydrometeorological Committee Documents" dated November 1985. The report provides up-to-date listings of the hydrometeorological stations and facilities that constitute the network.

Power Operating Plans and Annual Calculation of Downstream Benefits

The Treaty and related documents provide that the Entities are to agree annually on operating plans and on the resulting downstream power benefits for the sixth succeeding year of operation. These operating plans, prepared five years in advance, are called Assured Operating Plans. They represent the basic commitment of the Canadian Entity to operate the Canadian Treaty storage and provide the Entities with a basis for system planning. Canada's commitment to operate under an Assured Operating Plan is tied directly to the benefits produced by that plan. At the beginning of each operating year, a Detailed Operating Plan which includes Libby reservoir is prepared on the basis of current resources and loads to obtain results that may be more advantageous to both countries than those which would be obtained by operating in accordance with the Assured Operating Plan.

Near the end of the 1987-88 report year the Entities signed two agreements relating to changes in the principles and procedures used in preparing the assured operating plans and in calculating downstream power benefits. These agreements were based on Entity studies of the impact of several proposed changes to Treaty reservoir operating procedures and to the determination of downstream power benefits. Specific changes resulting from the agreements include the use of updated streamflows in all steps of the calculations, updated estimates of irrigation withdrawals and return flows, a revised definition of power loads and generating resources, the use of updated power system operating technology, and consistent application of operating procedures through all steps of the calculations. The Board agrees with the Entities' view that these studies represent the most thorough and complex examination of the technical aspects of the Columbia River Treaty since the ratification in 1964.

The Board also agrees that the changes provided in the two Entity agreements resolved the concerns which the Board had expressed in recent annual reports.

The document "Assured Operating Plan and Determination of Downstream Power Benefits for Operating Year 1992-93" was provided to the Board early in this report year. It normally would have been provided at the beginning of the previous report year but was delayed because of the time required by the Entities to complete the studies and negotiations necessary to finalize the two 1988 agreements. The document follows the same basic approach used in previous years and provides for optimum generation in both countries. It is the first operating plan to incorporate the new principles and procedures developed in the two 1988 Entity agreements.

The document "Assured Operating Plan and Determination of Downstream Power Benefits for Operating Year 1993-94" was provided to the Board at the end of this report year. It was delayed for the same reasons as the 1992-93 document. The 1993-94 document follows the same basic approach used in previous years, providing for optimum generation in both countries. It is based on the 1988 principles and procedures and, for the first time, includes firm energy shifting as part of the United States optimum operation. For comparison purposes the document includes an Alternative Operating Plan that excludes energy shifting. The comparison shows that firm energy shifting provides the Canadian Entitlement with an increase of 19.8 MW of average annual usable energy and a decrease of 6.9 MW of dependable capacity. The United States Entity will deliver this energy to the Canadian Entity during the 1993-94 operating year and will have the option of selecting either the Plan or the Alternative for use in the Detailed Operating Plan. The Board is currently reviewing this document and the Entities are considering how energy shifting will apply after termination of the Sales Agreement.

The Assured Operating Plan and the Determination of Downstream Power Benefits for Operating Year 1994-95, due at the beginning of the 1989-90 report year, have not yet been received. The Entities are developing these documents and hope to have returned to the required schedule of reporting by the end of the 1989-90 report year.

The Board notes that the document for operating year 1997-98, normally completed by July 1992, will determine a Canadian power entitlement not covered by the existing Sales Agreement.

Early in this report year the Entities provided the Board with the Detailed Operating Plan for Canadian Treaty storage and Libby reservoir for the operating year ending 31 July 1989. The Detailed Operating Plan for the operating year ending 31 July 1990 was forwarded to the Board after the end of the report year. These plans contain criteria for operating the Arrow, Duncan, Mica and Libby reservoirs.

In April 1984, the Entities reached an agreement relating to the initial filling of non-Treaty reservoirs, the use of non-Treaty storage, and Mica and Arrow reservoir refill enhancement. This agreement remained in effect throughout the report year. Operations under the agreement did not interfere with Treaty operations and were consistent with Treaty objectives.

The Northwest Power Planning Council was established by Act of Congress in 1980 to prepare a program for improvement of fish and wildlife in the Columbia River Basin and to develop a conservation and electric power plan for the Pacific Northwest. The Council, on 15 November 1982, adopted the Columbia River Basin Fish and Wildlife Program which establishes a water budget. This budget reserves 3.45 million acre-feet of storage upstream from Priest Rapids Dam on the Columbia River and 1.19 million acre-feet upstream from Lower Granite Dam on the Snake River. This storage is used by United States' project operators when it is required to improve low flows in the main rivers during the downstream migration of anadromous fish. Fisheries and native Indian interests control use of the storage for this purpose. The use of Canadian Treaty storage is advocated by the United States Northwest Power Planning Council in its Fish and Wildlife Program.

With regard to the use of Canadian Treaty storage to meet water budget purposes, the Board has stated in previous reports that the assured operating plans are to provide for optimum operation for power and flood control. The Board has also noted, however, that the Entities may agree to provide water for fish migration under detailed operating arrangements providing this does not conflict with Treaty requirements.

Flood Control Operating Plans

The Treaty provides that Canadian storage reservoirs will be operated by the Canadian Entity in accordance with operating plans designed to minimize flood damage in the United States and Canada.

The Columbia River Treaty Flood Control Operating Plan defines flood control operation of the Duncan, Arrow, Mica and Libby reservoirs. This plan was received from the Entities and reviewed by the Board in the 1972-73 report year and is still in effect.

POWERHOUSE INTERIOR
at Libby Dam.

Flow Records

Article XV(2)(a) of the Treaty specifies that the Permanent Engineering Board shall assemble records of flows of the Columbia and Kootenay Rivers at the Canada-United States of America boundary. Flows for this report year are tabulated in Appendix C for the Kootenai River at Porthill, Idaho and for the Columbia River at Birchbank, British Columbia.

OPERATION

General

The Columbia River Treaty Operating Committee was established by the Entities to develop operating plans for the Treaty storages and to direct operation of these storages in accordance with the terms of the Entity agreements.

During the report year the Treaty storage in Canada was operated by the Canadian Entity in accordance with:

— Columbia River Treaty Flood Control Operating Plan

— Detailed Operating Plan for Columbia River Treaty Storage 1 August 1988 through 31 July 1989

— Columbia River Treaty Hydroelectric Operating Plan, Assured Operating Plan for Operating Year 1988-89

— Columbia River Treaty Hydroelectric Operating Plan, Assured Operating Plan for Operating Year 1989-90.

In addition, the following agreements were in effect during this period:

— An agreement between the Entities dated 9 April 1984 relating to:

  — Agreement between British Columbia Hydro and Power Authority and Bonneville Power Administration Relating to: (1) Initial Filling of Non-Treaty Reservoirs, (2) The Use of Columbia River Non-Treaty Storage and (3) Mica and Arrow Reservoir Refill Enhancement

— Contract between Bonneville Power Administration and Mid-Columbia Purchasers Relating to Federal and Canadian Columbia River Storage

— Columbia River Treaty Entity Agreement on Principles for the Preparation of the Assured Operating Plan and Determination of Downstream Power Benefits, July 1988

— Columbia River Treaty Entity Agreement on Changes to Procedures for the Preparation of the Assured Operating Plan and Determination of Downstream Power Benefit Studies, August 1988.

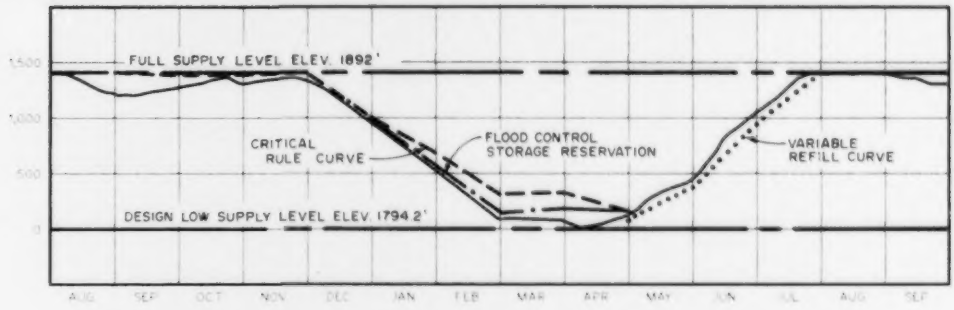
Power Operation

The three Canadian Treaty reservoirs, Duncan, Arrow and Mica, and the Libby reservoir in the United States were in full operation throughout this report year.

The total Treaty storage volume did not fill during the summer of 1988 as Arrow reservoir peaked at about 6.5 million acre-feet, about 0.6 million acre-feet below full. At the start of the report year drafting had started at both the Arrow and Duncan projects. Drafting Treaty storage at the Mica project began in October. Low inflows throughout the year at all reservoirs frequently resulted in below normal levels and required proportional drafting procedures.

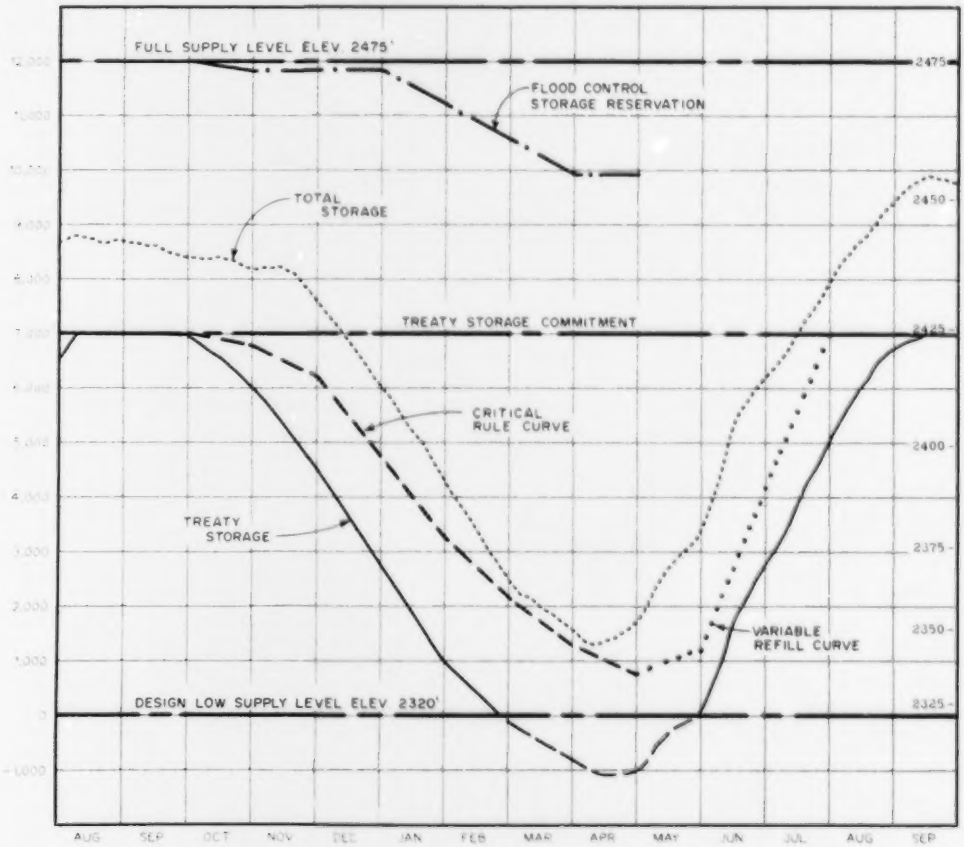
1989 was the third consecutive year of below average runoff for the Columbia River at The Dalles, although the runoff was significantly greater than in the previous two consecutive drought years. In spite of the low flows, Treaty storage refilled during the summer of 1989 at the Duncan and Arrow reservoirs. At the end of this report year drafting was underway, primarily at the Arrow project.

During the year some storage was transferred between Mica, Revelstoke and Arrow storage accounts as permitted under the Entities' Storage Agreement of April 1984. These storage transfers were accomplished without disrupting Treaty operations.


FULL SUPPLY LEVEL ELEV. 1892'
CRITICAL RULE CURVE
FLOOD CONTROL STORAGE RESERVATION
VARIABLE REFILL CURVE
DESIGN LOW SUPPLY LEVEL ELEV. 1794.2'
AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP

DUNCAN RESERVOIR

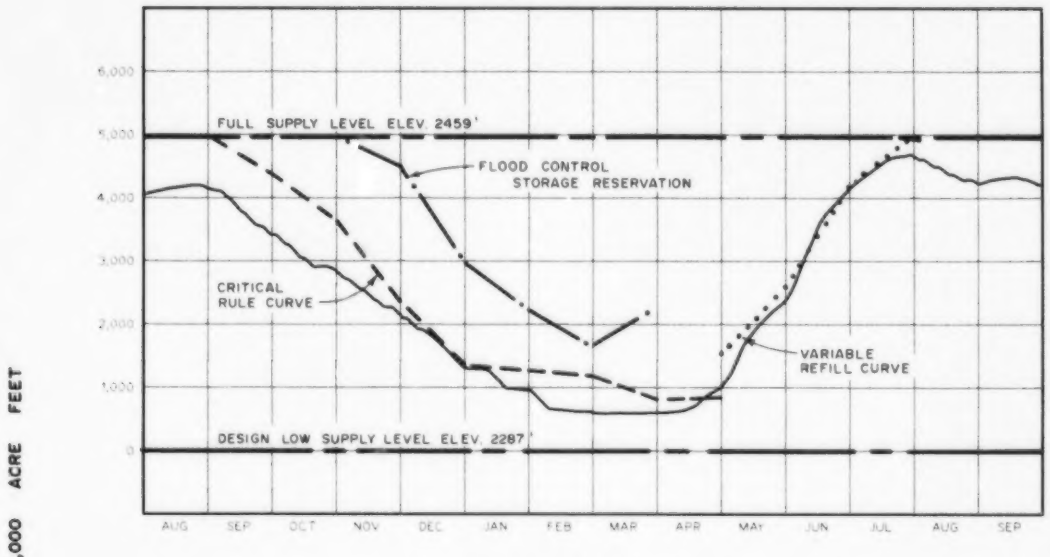
USABLE RESERVOIR STORAGE IN 1,000 ACRE FEET



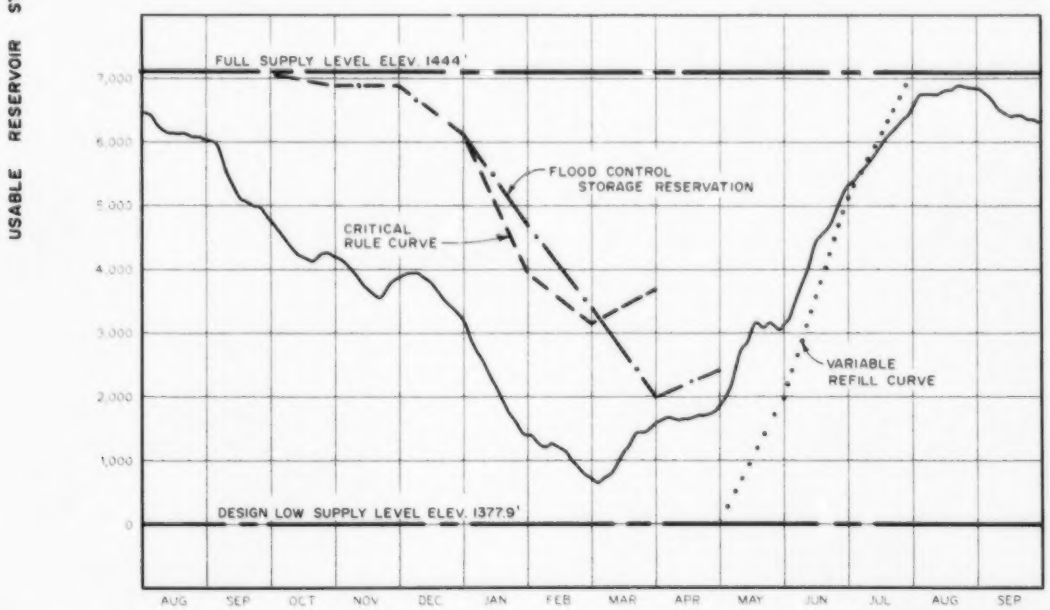
ELEVATION IN FEET (not applicable to Treaty Storage)

MICA RESERVOIR

HYDROGRAPHS — Duncan and Mica reservoir levels for the 14-month period ending 30 September 1989.



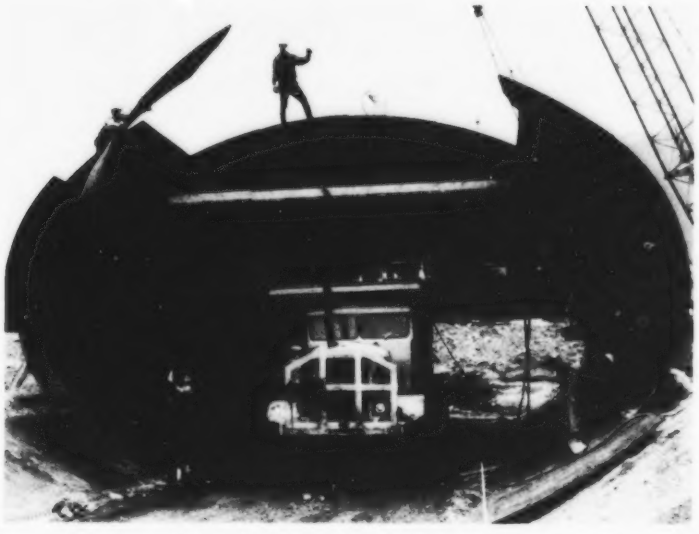
LIBBY RESERVOIR



ARROW RESERVOIR

HYDROGRAPHS — Libby and Arrow reservoir levels for the 14-month period ending 30 September 1989.

CULVERT ASSEMBLY
during construction
of haul roads at
Mica Dam, 1968.



Commencing in the 1984 report year, operation in the United States incorporated requirements of the Northwest Power Planning Council's Fish and Wildlife Program. This program specifies a water budget for use during the period 15 April to 15 June to meet minimum flow requirements for the downstream migration of anadromous fish. In this report year the water budget of 3.45 million acre-feet for Priest Rapids on the Columbia River was utilized between 22 May and 15 June.

Operation of the reservoirs is illustrated on pages 28 and 29 by hydrographs which show actual reservoir levels and some of the more important rule curves which govern operation of the Treaty storages. The Flood Control Storage Reservation curve specifies maximum month-end reservoir levels which will permit evacuation of the reservoir to control the forecast freshet. The Critical Rule Curve shows minimum month-end reservoir levels which should be maintained to enable the anticipated power demands to be met under adverse water supply conditions. The Variable Refill Curve shows reservoir elevations necessary to ensure refilling the reservoir by the end of July with a reasonable degree of confidence. Similar rule curves which apply to operation of the combined Canadian Treaty storages have also been provided to the Board.

Since Mica reservoir contains both Treaty and non-Treaty storage, a separate hydrograph is shown for Treaty storage in terms of acre-feet of storage volume, along with relevant rule curves. Also shown is a hydrograph of total reservoir storage in terms of both storage volumes and reservoir elevations.

At the start of the report year Duncan reservoir had begun drafting and was at elevation 1884.5 feet, 7.5 feet below full pool. From mid-September to late October, releases were curtailed to minimize spill at Kootenay River power projects. Drafting resumed until the end of October when releases were curtailed to 100 cfs and the reservoir filled to elevation 1890.1 feet on 24 November. Drafting then resumed until 10 April 1989 when the reservoir reached elevation 1795.3 feet, 1.1 feet above its minimum level of 1794.2 feet. Discharge was then reduced to 100 cfs and the reservoir filled rapidly. On 22 July 1989 discharge was increased to reduce the rate of filling. Duncan reservoir reached its full pool elevation of 1892 feet on 27 July and discharged inflow until 2 September when discharge was increased to help fill Kootenay Lake. At the end of September the reservoir elevation was 1886.6 feet.

Arrow reservoir was at elevation 1425.5 feet, 18.5 feet below its full level, at the start of the report year. Drafting continued until mid-November when Treaty storage releases from Mica were increased and the reservoir filled about four feet to 1418.7 feet by 9 December. Drafting resumed on 10 December and continued until 5 March when the reservoir reached the year's lowest level at 1387.6 feet, about 9.5 feet above its minimum pool level.

Refilling began on 6 March and on 31 July the reservoir reached elevation 1439.7 feet, about four feet below full pool level. During August, under proportional draft arrangements, the reservoir continued to fill and maintained its level at about elevation 1442 feet. The reservoir peaked at 1442.9 feet, 1.1 feet below full supply level, providing about 98 percent of its Treaty storage.

Drafting Treaty storage began on 2 September when project outflow was increased to 37,000 cfs. At the end of the report year the reservoir was at elevation 1438.3 feet.

Mica reservoir began the report year at elevation 2439.2 feet, nearly thirty six feet below full pool level. The Treaty storage was full but drafting of non-Treaty storage had begun. Drafting Treaty storage started in October. Heavy drafting through the fall and winter period resulted in the Treaty storage being completely drafted by 27 February. Non-Treaty storage, used to maintain the level of discharge specified in the Detailed Operating Plan, was then drafted and held in Arrow reservoir. By 13 April the reservoir was down to elevation 2345.2 feet. This was the lowest reservoir level reached since initial filling in 1976 and about 20 feet lower than last year's lowest level.

The reservoir began filling on 14 April. Discharge was held generally at zero until mid-June. The reservoir filled rapidly and non-Treaty storage was returned by 31 May. Discharges were increased during July and August but filling continued and the reservoir reached a maximum level of 2454.6 feet on 18 September, about 20 feet below full pool elevation. By 30 September the reservoir was at elevation 2453.3 feet.

On 1 October 1988, Libby reservoir had begun drafting and was at elevation 2422.7 feet, 36.3 feet below full pool level. Drafting continued through the fall and winter until 9 March when the reservoir reached its lowest level of 2321.2 feet.

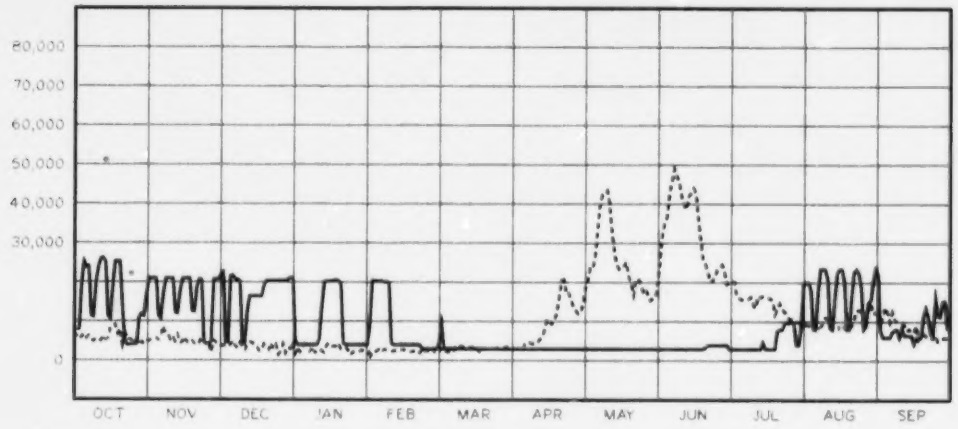
Reservoir inflows began rising in mid-April. Refill continued through the summer until a peak elevation of 2452.6 feet, about six feet below full pool, was reached on 31 July. Drafting of the reservoir began in August and by 30 September the reservoir was down to 2441.7 feet.

Flood Control Operation

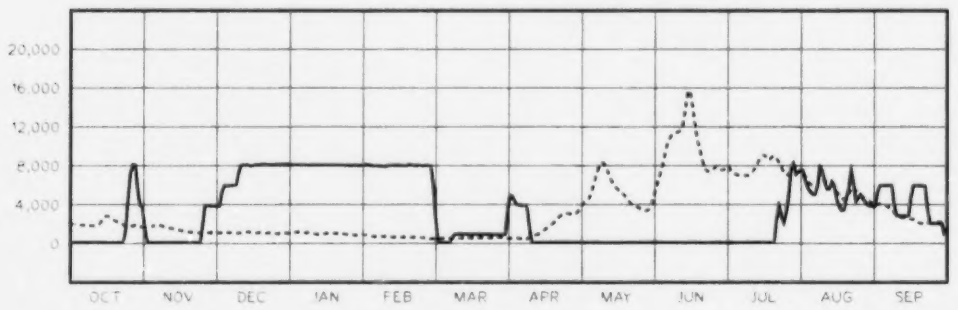
Flood control operation on a daily basis was not necessary in this report year due to very dry conditions in the Columbia River basin and below normal streamflows. Although daily flood control operations were not needed, the reservoirs were operated to provide flood control storage space as required by the Treaty.

SPILLWAY STRUCTURE
at Hugh Keenleyside Dam
prior to flooding.

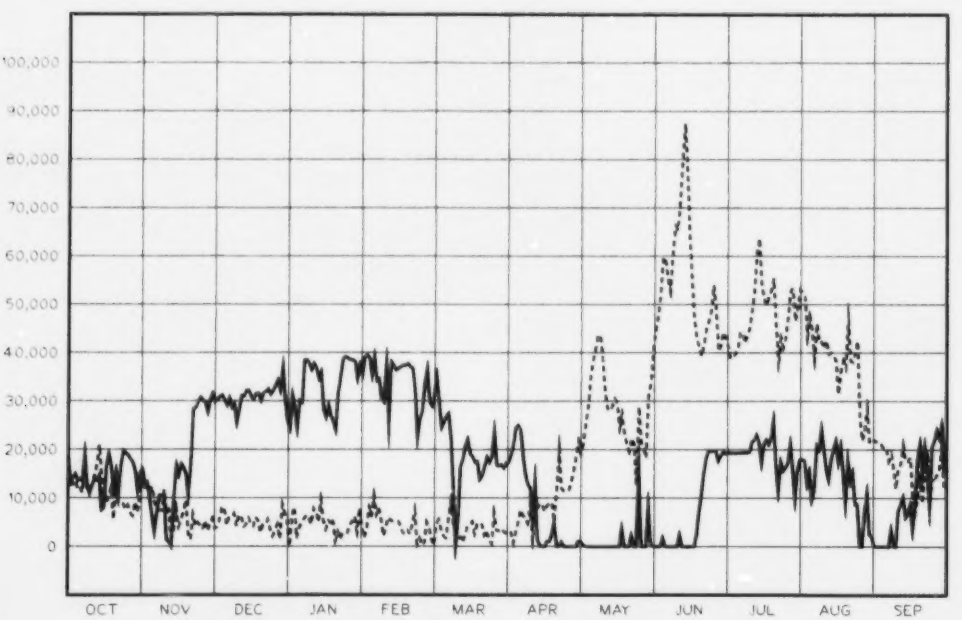
DISCHARGE IN CUBIC FEET PER SECOND



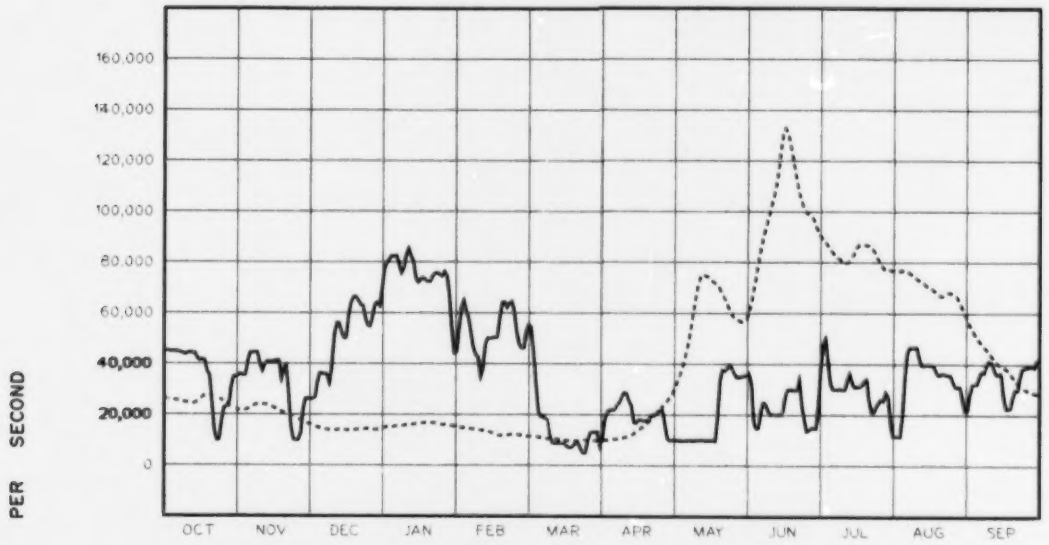
KOOTENAI RIVER AT LIBBY DAM



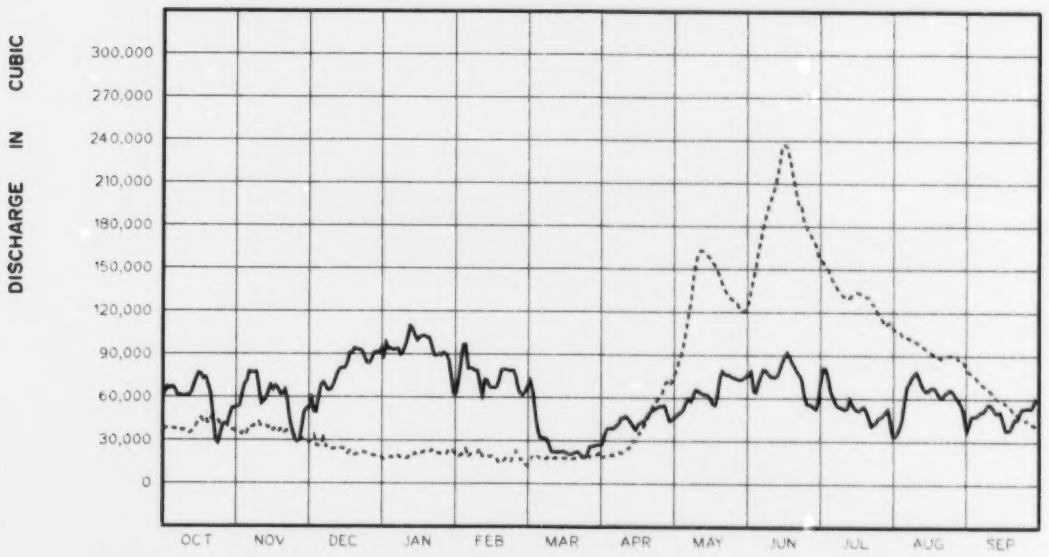
DUNCAN RIVER AT DUNCAN DAM



COLUMBIA RIVER AT MICA DAM



COLUMBIA RIVER AT HUGH KEENLEYSIDE DAM



COLUMBIA RIVER AT BIRCHBANK

LEGEND

Observed Flows

Pre-Project Flows

HYDROGRAPHS — Observed and pre-project flows for year ending 30 September 1989.

BENEFITS

Flood Control Provided

There were no significant flood control benefits this year. Without regulation the 1989 freshet would have resulted in below average peak discharges at Trail, British Columbia and at The Dalles, Oregon and would not have caused flooding.

It is estimated that the Duncan and Libby projects reduced the peak stage on Kootenay Lake by about five and one half feet and that the Duncan, Arrow, Mica and Libby projects reduced the peak stage of the Columbia River at Trail, British Columbia by about fourteen and one half feet. The effect of storage in the Duncan, Arrow, Mica and Libby reservoirs on flows at the sites and on flows of the Columbia River at Birchbank is illustrated on page 34 by hydrographs which show both the actual discharges and the flows that would have occurred if the dams had not been built. It is noted that the hydrograph showing pre-project conditions for Birchbank has been computed on the assumption that the effects of Duncan, Arrow, Mica and Libby regulation and of the regulation provided by the Corra Linn development on Kootenay Lake have been removed.

The operation of Columbia Basin reservoirs for the system as a whole reduced the natural annual peak discharge of the Columbia River near The Dalles, Oregon from about 513,000 cfs to 312,000 cfs.

All payments required by Article VI(1) as compensation for flood control provided by the Canadian Treaty storage projects have been made by the United States to Canada; the final payment was made on 29 March 1973 when the Mica project was declared operational.

Power Benefits

Downstream power benefits in the United States which arise from operation of the Canadian Treaty storage were pre-determined for the first thirty years of operation of

SPORT FISHING
on Arrow Lakes.

each project and the Canadian one-half share was sold in the United States under the terms of the Canadian Entitlement Purchase Agreement. The United States Entity delivers capacity and energy to Columbia Storage Power Exchange participants as purchasers of the Canadian Entitlement. The benefits of additional generation made possible on the Kootenay River in Canada as a result of regulation provided by Libby, and generation at the Mica and Revelstoke projects, are retained wholly within Canada. The benefits from Libby regulation which occur downstream in the United States are not shareable under the Treaty.

Recovery of the downstream benefits will commence 1 April 1998 and be fully completed by 1 April 2003.

Other Benefits

By agreement between the Entities, as in previous report years, streamflows were regulated for non-power purposes such as accommodating construction in river channels and providing water to assist the downstream migration of juvenile fish in the United States. These arrangements were implemented under the Detailed Operating Plan and provided mutual benefits to the Entities.

CONCLUSIONS

1. The Duncan, Arrow, Mica and Libby projects have been operated in conformity with the provisions of the Treaty. Operation reflected detailed operating plans developed by the Entities, the flood control operating plan for Treaty reservoirs, and an agreement between the Entities relating to the use of non-Treaty storage and refill enhancement of Mica and Arrow reservoirs. Operation under this agreement did not conflict with normal Treaty operations.

2. The Entities have reached agreement on the detailed operating plan for Columbia River Treaty Storage for 1989-90.

3. Entity evaluations pertaining to development of the hydrometeorological network, power operating plans, and the calculation of downstream power benefits are proceeding. The Assured Operating Plan and the Determination of Downstream Power Benefits for operating years 1993-94, delayed as a result of the Entity studies and two agreements in 1988, have been received. The corresponding documents for 1994-95, due at the beginning of the 1989-90 report year have not yet been received. The Entities expect to have these documents available early in 1990.

4. The two Entity agreements signed in the previous report year resolved concerns which the Board had expressed in recent annual reports. They clarified operating procedures and how downstream power benefits will be calculated, resolved issues which had been under discussion for several years, and facilitate meeting Treaty objectives.

5. The objectives of the Treaty are being met.

APPENDIX A

COLUMBIA RIVER TREATY PERMANENT ENGINEERING BOARD

United States	Canada
Members	
Mr. Lloyd A. Duscha, Chairman Deputy Director, Directorate of Military Programs, H.Q., U.S. Army Corps of Engineers, Washington, D.C.	Mr. G.M. MacNabb, Chairman R.R. #2, North Gower, Ontario
Mr. Ronald H. Wilkerson 4655 Highway 200 East, Missoula, Montana	Mr. D.H. Horswill 1) Deputy Minister, Ministry of Energy, Mines and Petroleum Resources, Victoria, B.C.
Alternates	
Mr. Herbert H. Kennon Chief, Engineering Division, Directorate of Military Programs, H.Q., U.S. Army Corps of Engineers, Washington, D.C.	Mr. E.M. Clark 4376 Starlight Way, North Vancouver, B.C.
Mr. Thomas L. Weaver Assistant Administrator for Engineering, Western Area Power Administration, Department of Energy, Golden, Colorado	Dr. D.A. Kasianchuk 2) Comptroller of Water Rights, Ministry of Environment, Victoria, B.C.
Secretaries	
Mr. S.A. Zanganeh Hydraulics & Hydrology Branch, Civil Works Directorate, H.Q., U.S. Army Corps of Engineers, Washington, D.C.	Mr. E.M. Clark 4376 Starlight Way, North Vancouver, B.C.

1) Vice Mr. T.R. Johnson as of 12 October 1989
2) Vice Mr. H.M. Hunt

APPENDIX A

COLUMBIA RIVER TREATY PERMANENT ENGINEERING BOARD

Record of Membership

Members

United States		Canada	
Mr. Wendell E. Johnson 1)	1964-1970	Mr. G.M. MacNabb 1)	1964-
Mr. Morgan E. Dubrow	1964-1970	Mr. A.F. Paget	1964-1973
Mr. John W. Neuberger	1970-1973	Mr. V. Raudsepp	1973-1974
Mr. Joseph B. Caldwell 1)	1971-1973	Mr. B.E. Marr	1974-1987
Mr. Homer B. Willis 1)	1973-1979	Mr. T.R. Johnson	1987-1988
Mr. C. King Mallory	1973-1975	Mr. D.H. Horswill	1989-
Mr. Raymond A. Peck, Jr.	1976-1977		
Mr. J. Emerson Harper	1978-1988		
Mr. Lloyd A. Duscha 1)	1979-		
Mr. Ronald H. Wilkerson	1988-		

Alternates

Mr. Fred L. Thrall	1964-1974	Mr. E.M. Clark	1964-
Mr. J. Emerson Harper	1964-1978	Mr. J.T. Rothwell	1964-1965
Mr. Alex Shwaiko	1974-1987	Mr. H.M. Hunt	1966-1988
Mr. Thomas L. Weaver	1979-	Dr. D.A. Kasianchuk	1988-
Mr. Herbert H. Kennon	1987-		

Secretaries

Mr. John W. Roche	1965-1969	Mr. E.M. Clark	1964-
Mr. Verle Farrow	1969-1972		
Mr. Walter W. Duncan	1972-1978		
Mr. S.A. Zanganeh	1978-		

1) Chairman

APPENDIX B

COLUMBIA RIVER TREATY ENTITIES

United States

Mr. James J. Jura, Chairman

Administrator, Bonneville
Power Administration,
Department of Energy,
Portland, Oregon

Brigadier General Pat M. Stevens, IV

Division Engineer,
U.S. Army Engineer Division, North Pacific,
Portland, Oregon

Canada

Mr. L.I. Bell, Chairman

Chairman, British Columbia
Hydro and Power Authority,
Vancouver, B.C.

APPENDIX C

RECORD OF FLOWS

AT THE

INTERNATIONAL BOUNDARY

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	19,900	18,900	21,200	12,700	6,320	4,240	6,220	16,900	15,400	7,410	10,500	24,000
2	9,820	20,800	23,000	7,200	11,900	4,360	6,060	19,800	17,300	6,620	18,800	19,600
3	8,550	21,500	19,000	5,780	21,400	6,340	6,010	22,500	18,200	6,500	20,200	9,790
4	9,240	22,100	7,690	5,860	23,400	8,520	5,730	23,700	17,900	6,300	20,500	7,360
5	21,900	19,700	11,100	6,280	23,200	4,710	5,780	24,500	17,600	5,900	17,600	7,200
6	23,700	15,000	23,400	6,430	22,800	4,310	7,110	26,100	17,400	5,840	10,000	7,310
7	24,000	15,100	22,900	6,120	22,800	4,320	9,700	29,000	17,400	5,760	9,890	7,070
8	20,900	21,600	23,200	5,830	22,400	4,310	12,800	31,200	16,500	5,450	20,100	8,460
9	12,300	23,000	22,800	5,790	21,800	4,420	12,700	30,600	15,900	5,570	23,800	8,610
10	11,900	23,100	12,300	5,920	17,700	4,900	11,300	30,500	14,800	5,590	24,800	8,300
11	21,300	22,700	6,980	5,900	7,120	5,410	10,400	28,600	13,600	5,410	24,700	6,800
12	24,400	20,400	7,320	8,250	5,830	5,860	10,200	24,300	12,800	5,480	19,400	8,420
13	25,800	14,400	16,500	15,200	5,740	6,280	10,500	20,900	12,100	5,490	10,700	7,370
14	25,800	14,000	17,300	19,700	5,450	6,360	11,900	18,400	11,600	5,580	9,530	7,320
15	21,500	20,500	17,000	20,400	5,340	6,210	14,500	17,200	11,300	5,520	19,000	7,280
16	13,800	21,900	17,100	20,500	5,350	6,090	18,300	17,000	11,300	6,390	23,500	7,190
17	15,100	22,200	17,200	20,700	5,140	5,660	19,600	17,600	10,900	5,180	24,500	5,900
18	24,500	22,200	17,000	21,100	5,100	5,480	18,600	18,900	10,100	5,150	23,900	6,630
19	26,200	20,100	18,000	21,200	5,310	5,290	18,300	17,600	9,520	5,040	18,600	6,650
20	26,400	14,500	22,800	21,300	5,060	5,200	20,300	15,800	9,490	4,880	10,200	6,670
21	24,700	14,300	22,700	17,600	5,230	5,160	24,800	14,500	9,040	4,730	9,370	11,300
22	13,200	20,600	22,800	7,520	5,130	5,150	27,500	13,900	9,000	8,590	18,900	13,300
23	6,950	22,600	22,800	6,510	4,890	5,170	26,300	14,900	9,050	8,620	23,400	11,200
24	5,770	19,200	23,100	6,150	4,390	5,150	23,300	16,000	8,590	8,710	24,700	7,700
25	5,620	8,090	23,200	5,790	4,380	5,100	20,800	14,900	8,480	9,770	23,300	8,380
26	5,720	6,590	22,700	6,130	4,360	5,270	18,900	14,000	8,440	10,200	18,600	14,700
27	5,600	6,460	22,000	5,820	4,400	5,440	17,900	13,600	8,370	9,960	11,100	12,200
28	5,710	10,300	21,600	5,780	4,460	5,840	16,700	15,300	8,160	10,300	12,000	11,600
29	11,600	20,000	21,600	6,080		6,310	15,700	15,500	7,890	9,440	15,700	14,900
30	11,800	21,400	22,000	5,740		6,360	15,700	14,500	7,810	5,610	17,700	15,300
31	12,000		22,900	6,150		6,240		14,400		5,340	21,700	
Mean	16,000	18,100	19,100	10,400	10,200	5,470	14,800	19,800	12,200	6,660	18,000	9,950

KOOTENAI RIVER AT PORTHILL, IDAHO — Daily discharges for the year ending 30 September 1989 in cubic feet per second.

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	67,500	53,300	53,000	89,000	70,600	64,600	27,400	45,000	75,500	58,900	33,900	37,100
2	63,600	53,700	59,300	98,200	84,600	67,700	27,600	46,400	76,500	72,400	33,500	42,000
3	67,500	61,400	50,100	93,600	96,900	72,100	33,700	47,700	78,800	81,200	36,400	47,700
4	66,000	68,900	49,800	94,100	97,100	65,100	38,100	49,400	64,900	80,900	40,400	48,100
5	67,500	71,000	61,100	93,100	80,100	51,700	39,000	50,400	64,200	74,900	46,200	48,100
6	66,000	78,000	68,900	93,400	80,400	38,700	38,900	52,700	71,100	65,100	59,500	49,600
7	61,800	77,300	70,600	93,900	80,300	32,200	39,000	57,500	76,100	61,000	68,500	51,300
8	61,400	77,300	67,500	89,800	78,900	32,400	40,500	59,600	80,200	56,400	71,100	51,100
9	61,100	77,700	65,000	91,800	78,800	31,900	42,000	57,700	79,900	54,600	74,900	53,700
10	60,700	67,500	65,300	96,000	69,000	31,500	45,800	62,500	77,300	54,000	77,000	56,300
11	61,100	55,400	68,200	102,000	61,600	27,600	46,100	66,000	75,100	53,400	78,900	55,900
12	61,400	57,200	72,700	110,000	72,900	22,300	47,200	65,300	75,100	52,200	74,600	53,600
13	63,200	59,000	77,700	108,000	72,000	22,400	45,300	63,800	75,000	53,400	69,600	50,300
14	68,500	63,900	80,200	103,000	67,300	22,200	43,200	62,900	75,800	59,700	66,700	50,200
15	73,500	68,500	80,500	99,500	67,200	22,100	40,000	62,400	80,500	56,200	65,000	50,700
16	77,000	65,300	80,500	102,000	67,200	22,200	37,900	62,100	85,800	53,500	65,700	44,700
17	76,300	68,200	84,400	103,000	67,400	22,600	41,200	59,400	89,300	51,900	67,600	38,000
18	72,700	66,400	91,100	103,000	72,300	22,100	42,600	55,700	92,100	51,600	67,700	38,100
19	73,800	62,200	91,500	102,000	79,500	20,800	43,600	55,000	88,500	53,400	66,300	38,400
20	68,500	62,500	94,300	102,000	79,800	20,500	44,800	62,300	85,200	54,400	62,900	42,100
21	62,200	65,300	93,600	95,600	79,700	20,900	47,800	74,400	82,200	51,200	61,200	45,800
22	47,300	58,300	93,200	89,400	79,100	22,100	50,200	79,000	78,400	46,400	61,700	45,700
23	30,400	44,100	92,500	89,400	78,700	22,400	51,700	77,100	76,500	40,600	64,000	49,400
24	27,900	37,100	87,900	90,700	79,200	20,800	52,200	76,300	73,600	42,300	64,900	53,200
25	34,100	30,500	84,000	89,400	74,400	18,600	53,600	76,300	62,500	43,300	66,400	53,300
26	40,600	28,800	83,700	91,600	65,200	18,500	54,400	74,900	56,300	46,800	65,500	54,100
27	41,700	30,300	86,500	89,900	62,700	21,200	54,200	74,400	55,700	46,800	62,400	53,800
28	41,700	39,200	91,100	86,100	62,300	26,200	54,600	73,300	55,300	48,600	60,200	53,800
29	47,000	50,100	91,800	74,800		26,500	49,000	72,900	53,800	50,800	57,300	57,300
30	52,600	52,300	90,800	62,800		26,600	43,900	73,200	52,600	52,500	54,100	60,700
31	52,600		93,900	62,300		27,400		74,100		43,000	46,600	
Mean	58,600	58,400	78,100	93,200	75,200	31,100	43,900	63,500	73,800	55,200	61,000	49,100

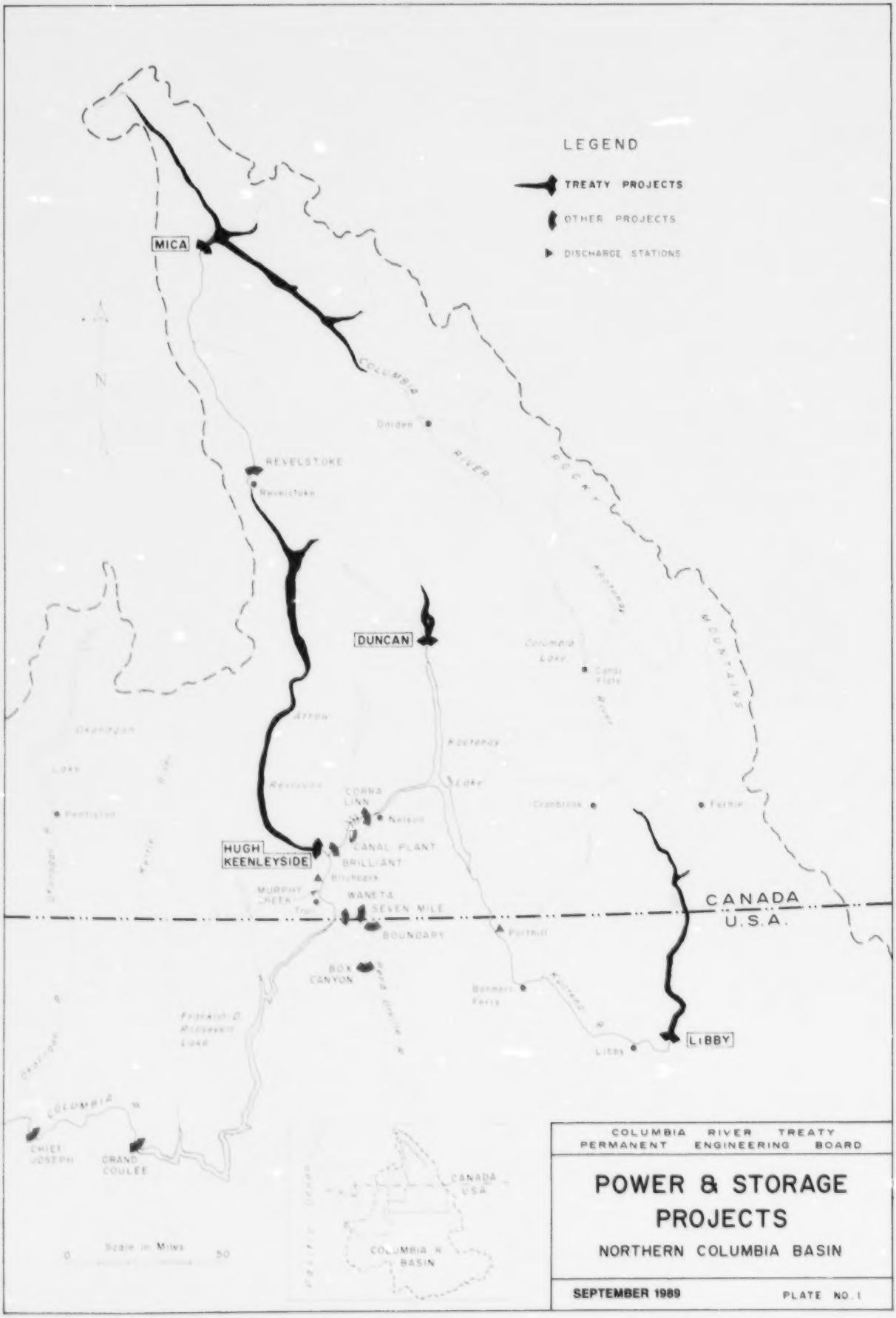
COLUMBIA RIVER AT BIRCHBANK, B.C. — Daily discharges for the year ending 30 September 1989 in cubic feet per second.

APPENDIX D

PROJECT INFORMATION

Power and Storage Projects,
Northern Columbia Basin — Plate No. 1

Project Data
Duncan Project — Table No. 1
Arrow Project — Table No. 2
Mica Project — Table No. 3
Libby Project — Table No. 4



COLUMBIA RIVER TREATY
PERMANENT ENGINEERING BOARD

POWER & STORAGE PROJECTS

NORTHERN COLUMBIA BASIN

SEPTEMBER 1989

PLATE NO. 1

TABLE 1

DUNCAN PROJECT

Duncan Dam and Duncan Lake

Storage Project	
Construction began	17 September 1964
Storage became fully operational	31 July 1967
Reservoir	
Normal Full Pool Elevation	1,892 feet
Normal Minimum Pool Elevation	1,794.2 feet
Surface Area at Full Pool	18,000 acres
Total Storage Capacity	1,432,500 ac-ft
Usable Storage Capacity	1,400,000 ac-ft
Treaty Storage Commitment	1,400,000 ac-ft
Dam, Earthfill	
Crest Elevation	1,907 feet
Length	2,600 feet
Approximate height above riverbed	130 feet
Spillway — Maximum Capacity	47,700 cfs
Discharge Tunnels — Maximum Capacity	20,000 cfs
Power Facilities	
None	

TABLE 2

ARROW PROJECT

Hugh Keenleyside Dam and Arrow Lakes

Storage Project	
Construction began	March 1965
Storage became fully operational	10 October 1968
Reservoir	
Normal Full Pool Elevation	1,444 feet
Normal Minimum Pool Elevation	1,377.9 feet
Surface Area at Full Pool	130,000 acres
Total Storage Capacity	8,337,000 ac-ft
Usable Storage Capacity	7,100,000 ac-ft
Treaty Storage Commitment	7,100,000 ac-ft
Dam, Concrete Gravity and Earthfill	
Crest Elevation	1,459 feet
Length	2,850 feet
Approximate height above riverbed	170 feet
Spillway — Maximum Capacity	240,000 cfs
Low Level Outlets — Maximum Capacity	132,000 cfs
Power Facilities	
None	

TABLE 3

MICA PROJECT

Mica Dam and Kinbasket Lake

Storage Project	
Construction began	September 1965
Storage became fully operational	29 March 1973
Reservoir	
Normal Full Pool Elevation	2,475 feet
Normal Minimum Pool Elevation	2,320 feet
Surface Area at Full Pool	106,000 acres
Total Storage Capacity	20,000,000 ac-ft
Usable Storage Capacity	
Total	12,000,000 ac-ft
Commitment to Treaty	7,000,000 ac-ft
Dam, Earthfill	
Crest Elevation	2,500 feet
Length	2,600 feet
Approximate height above foundation	800 feet
Spillway — Maximum Capacity	150,000 cfs
Outlet Works — Maximum Capacity	37,400 cfs
Power Facilities	
Designed ultimate installation	
6 units at 434 mw	2,604 mw
Power commercially available	December 1976
Presently installed	
4 units at 434 mw	1,736 mw
Head at full pool	600 feet
Maximum Turbine Discharge	
of 4 units at full pool	38,140 cfs

TABLE 4

LIBBY PROJECT

Libby Dam and Lake Koocanusa

Storage Project	
Construction began	June 1966
Storage became fully operational	17 April 1973
Reservoir	
Normal Full Pool Elevation	2,459 feet
Normal Minimum Pool Elevation	2,287 feet
Surface Area at Full Pool	46,500 acres
Total Storage Capacity	5,869,000 ac-ft
Usable Storage Capacity	4,980,000 ac-ft
Dam, Concrete Gravity	
Deck Elevation	2,472 feet
Length	3,055 feet
Approximate height above riverbed	370 feet
Spillway — Maximum Capacity	145,000 cfs
Low Level Outlets — Maximum Capacity	61,000 cfs
Power Facilities	
Designed ultimate installation	
8 units at 105 mw	840 mw
Power commercially available	24 August 1975
Presently installed	
5 units at 105 mw	525 mw
Head at full pool	352 feet
Maximum Turbine Discharge	
of 5 units at full pool	26,500 cfs